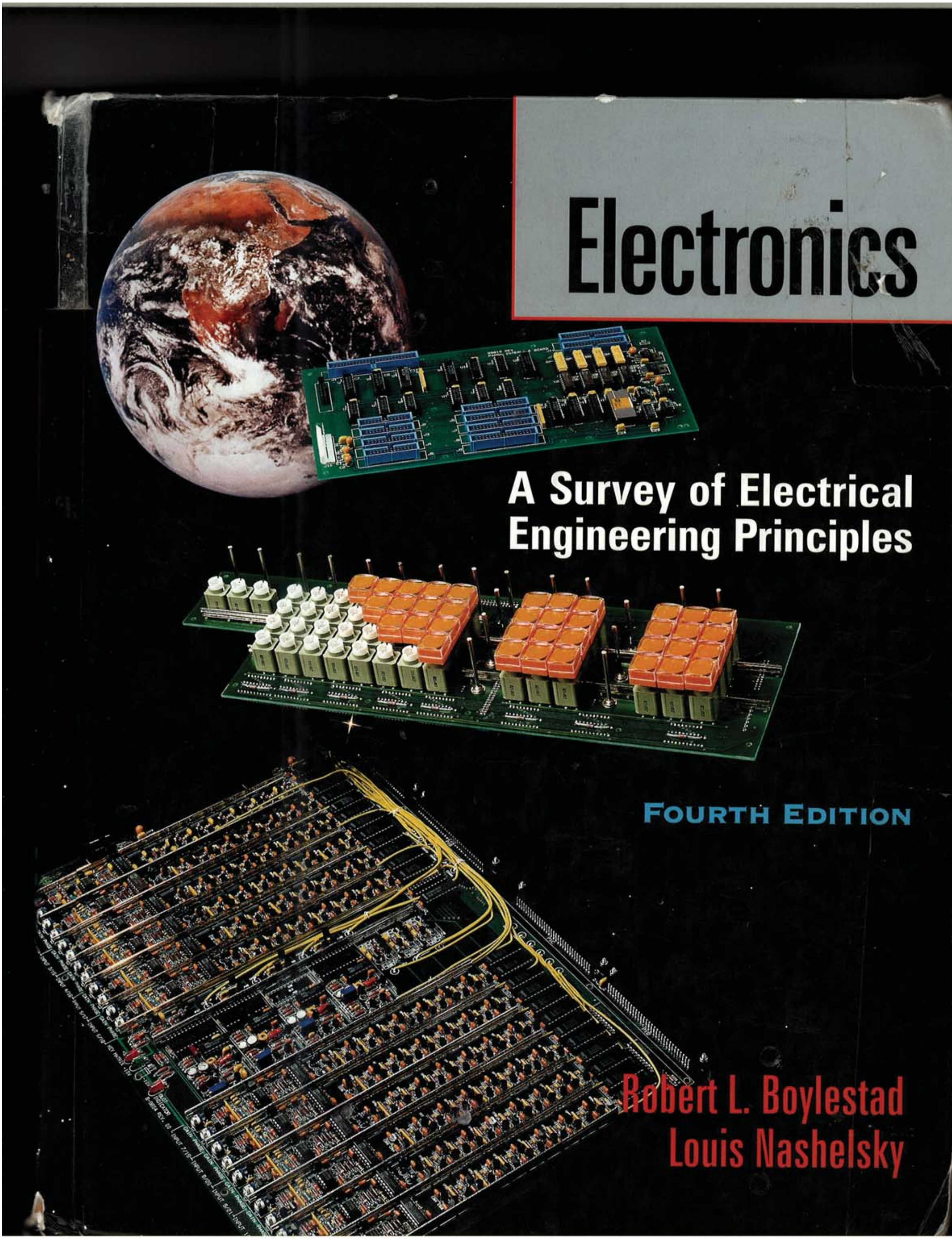
EXHIBIT 11


Electronics
A Survey of Electrical Engineering Principles
FOURTH EDITION
Robert L. Boylestad
Louis Nashelsky

Electronics

A Survey of Electrical Engineering Principles

Fourth Edition

Robert Boylestad
Louis Nashelsky

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The peak-inverse-voltage (PIV) rating of the diode is of primary importance in the design of rectification systems. Recall that it is voltage rating that must not be exceeded in the reverse-bias region or the diode will enter the Zener avalanche region. The required PIV rating for the half-wave rectifier can be determined from Fig. 7.32, which displays the reverse-biased diode in Fig. 7.26 with maximum applied voltage. Applying Kirchhoff's voltage law, it is fairly obvious that the PIV rating of the diode must equal or exceed the peak value of the applied voltage. Therefore,

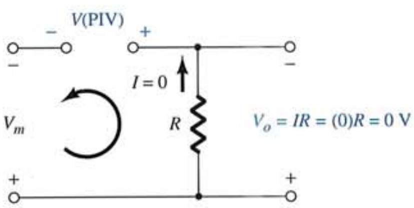

FIG. 7.32
Determining the required PIV rating for the half-wave rectifier.

$$\boxed{\text{PIV rating} = V_m}_{\text{half-wave rectifier}} \tag{7.2}$$

7.6 FULL-WAVE RECTIFICATION

The dc level obtained from a sinusoidal input can be improved 100% using a process called *full-wave rectification.* The most familiar network for performing such a function appears in Fig. 7.33 with its four diodes in a *bridge* configuration. During the period $t = 0$ to $T/2$ the polarity of the input is as shown in Fig. 7.34. The resulting polarities across the ideal diodes are also shown in Fig. 7.34 to reveal that D_2 and D_3 are conducting while D_1 and D_4 are in the *off* state. The net result is the configuration in Fig. 7.35 with its indicated current and polarity across R. Since the diodes are ideal, the load voltage $v_o = v_i$, as shown in the same figure.

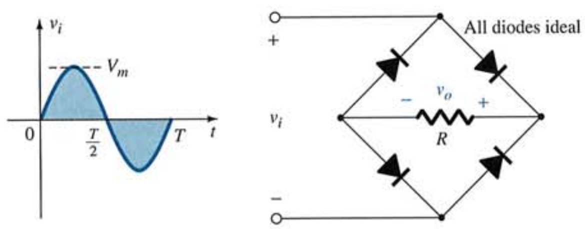

FIG. 7.33
Full-wave bridge rectifier.

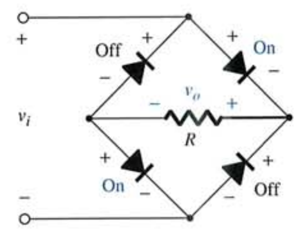

FIG. 7.34
Network in Fig. 7.33 for the period 0 → T/2 of the input voltage V_i.

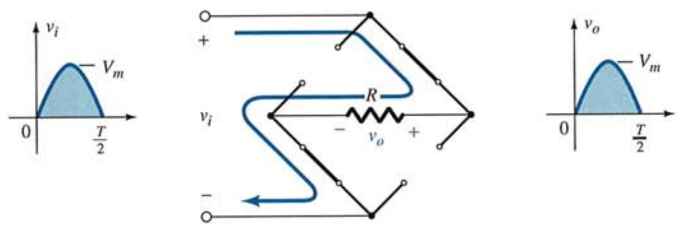

FIG. 7.35

For the negative region of the input the conducting diodes are D_1 and D_4, resulting in the configuration in Fig. 7.36. The important result is that the polarity across the load resistor R is the same as in Fig. 7.34, establishing a second positive pulse, as shown in Fig. 7.36. Over one full cycle the input and output voltages appear as shown in Fig. 7.37.

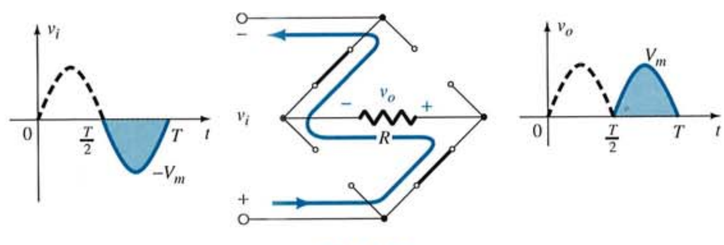

FIG. 7.36

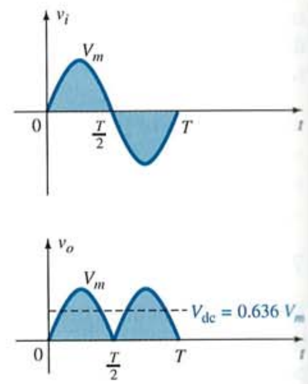

FIG. 7.37

Since the area above the axis for one full cycle is now twice that obtained for a half-wave system, the dc level has also been doubled and

$$\boxed{\text{average (dc value)} = 0.636\ V_m} \tag{7.3}$$

The required PIV of each diode (ideal) can be determined from Fig. 7.38 obtained at the peak of the positive region of the input signal. For the indicated loop the maximum voltage across R is V_m and

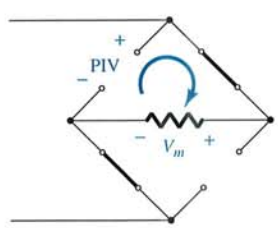

FIG. 7.38

$$\boxed{\text{PIV} = V_m} \tag{7.4}$$

full-wave bridge rectifier

EXAMPLE 7.8 Determine the output waveform for the network in Fig. 7.39 and calculate the output dc level and the required PIV of each diode.

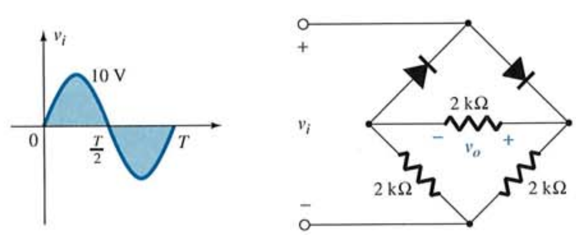

FIG. 7.39

Solution: The network will appear as shown in Fig. 7.40 for the positive region of the input voltage. Redrawing the network will result in the

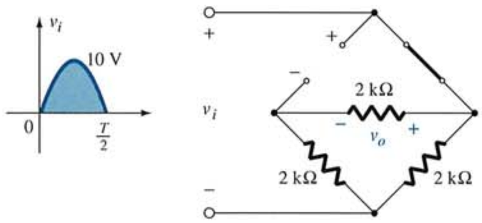

FIG. 7.40

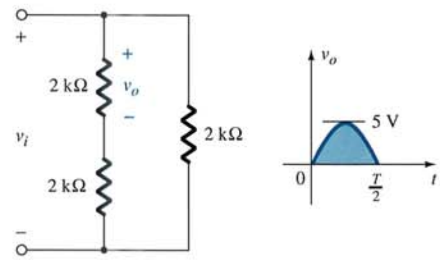

FIG. 7.41

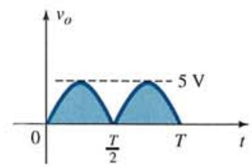

FIG. 7.42

configuration in Fig. 7.41, where $v_o = \frac{1}{2} v_i$ or $V_{o(\max)} = \frac{1}{2} V_{i(\max)} = \frac{1}{2}(10\text{ V}) =$ 5 V, as shown in Fig. 7.41. For the negative part of the input the roles of the diodes will be interchanged and v_o will appear as shown in Fig. 7.42.

The effect of removing two diodes from the bridge configuration is therefore to reduce the available dc level to

$$V_{dc} = 0.636(5\text{ V}) = \mathbf{3.18\text{ V}}$$

or that available from a half-wave rectifier with the same input. However, the PIV as determined from Fig. 7.38 is equal to the maximum voltage across R, which is 5 V or half of that required for a half-wave rectifier with the same input.

7.7 CLIPPERS

There are a variety of diode networks called *clippers* that have the ability to "clip" off a portion of the input signal without distorting the remaining part of the alternating waveform. The half-wave rectifier described in Section 7.5 is an example of the simplest form of diode clipper—one resistor and one diode. Depending on the orientation of the diode the positive or negative region of the input signal is clipped off.

There are two general categories of clippers: series and parallel. The series configuration is defined as one where the diode is in series with the load, while the parallel variety has the diode in a branch parallel to the load.

The response of the series configuration in Fig. 7.43(a) to a variety of alternating waveforms is provided in Fig. 7.43(b). Although first introduced as a half-wave rectifier (for sinusoidal waveforms), there are no boundaries on the type of signals that can be applied to a clipper.

The addition of a dc supply such as shown in Fig. 7.44 can have a pronounced effect on the output of a clipper as clearly revealed by the review table in Fig. 7.58.

There is no set procedure for analyzing networks like the one in Fig. 7.44, but there are a few thoughts to keep in mind as you work toward a solution.

1. *Make a mental sketch of the response of the network based on the direction of the diode and the applied voltage levels.* For the network in Fig. 7.44, the direction of the diode suggests that the signal v_i must be positive to turn it on. The dc supply further requires that the voltage v_i be greater than E volts to turn the diode on.